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SIXTY-SEVENTH

ANNUAL REPORT

OF THE

DIRECTOR

OF

THE ASTRONOMICAL OBSERVATORY

OF

HARVARD COLLEGE

FOR THE YEAR ENDING SEPTEMBER 30, 1912

BY

EDWARD C. PICKERING

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CAMBRIDGE, MASS.
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THE OBSERVATORY

To the President of the University: —

Sir, — The plan of work advocated in recent reports has been greatly improved and extended during the past year. When a method, which commends itself to other astronomers, has been developed, if it can be applied to a large number of objects, results of great value will be achieved. It is of the first importance that the accuracy of the measures shall not be diminished, but with this condition the value is often proportional to the number of objects observed. Examples of such researches are the Revised Draper Catalogue and the Durchmusterung of Selected Areas, described more in detail below. As increased efficiency is of great importance, many of the methods of " Scientific Management " can be applied to advantage. The continual requests for facts which can only be obtained from the Harvard photographs is evidence that these lines of work are approved by astronomers and no other observatory is prepared or inclined to supply this demand. A large number of investigations, some of them requiring several years for their completion, are now in progress here. Another important feature of our present work is the extensive coöperation with other observatories and astronomical associations, both in America and Europe.

The retirement of Professor Arthur Searle, at the age of seventy-five years, deprives the Observatory of an active and efficient officer after a service of forty-three years. His devotion of a quarter of a century of his life to the discussion and reduction of the zone $-10°$ to $-14°$ provides one of the largest contributions of America, to Astronomy. Fortunately, he has been enabled to see this great work practically completed.

The Observatory has suffered a serious loss by the death of Professor A. Lawrence Rotch, Director of the Blue Hill Meteorological Observatory. His friendly coöperation with this Observatory has prevented needless duplication of work and has filled seven volumes of our Annals. These investigations have done much to change Meteorology from the mere work of collecting routine observations to a living science giving us the laws of the atmosphere. His study of the upper air by means of kites and balloons placed him in the front rank in these investigations. It is hoped that his wish, expressed in the Preface to Volume 20 of our Annals, for "the ultimate consolidation of the two institutions," may be fulfilled.

OBSERVATORY INSTRUMENTS

East Equatorial. — The observations with the 15-inch East Equatorial have been made by Professor O. C. Wendell, and have been of the same general character as in previous years. More than nine thousand photometric comparisons have been made, mainly with the polarizing photometer with achromatic prisms. A part of the measurements relate to stars of the Algol type, others to stars whose variability is small, or doubtful, this instrument permitting slight changes to be detected with certainty. 1,380 settings have been made on Nova Geminorum No. 2, and its comparison stars. A series of measurements, comprising 752 settings, has also been made on S Ursae Majoris while its light was diminishing. The observations of a selected list of Fourth Type stars have been continued, 368 settings having been made. The brightness of the nucleus of Brooks' Comet 1911c was observed on two nights. With a second photometer, adapted to the measure of adjacent objects, four eclipses of Jupiter's satellites have been observed, making 914 in all, and 224 settings have been made on δ Orionis, suspected of variability. Other observations of a miscellaneous character have also been obtained.

Meridian Circle. — The work of this instrument may now be regarded as completed, except that the study of the proper motion of the stars in the zone $-10°$ to $-14°$ is still in progress. Two great investigations have been completed with it, the zone $+50°$ to $+55°$ containing 8,627 stars, and the zone $-10°$ to $-14°$ containing 8,337 stars. Each of these investigations occupied the time of an observer and corps of computers for more than twenty years. The results fill eleven of the quarto volumes of the Annals, and the expense in salaries alone was about a hundred thousand dollars in each case. The instrument is still in use for time observations. It is believed that its work could now be advantageously replaced by photography, and experiments are in progress here with that end in view. It certainly would not be wise to undertake any large investigation with it, in its present condition. Great improvement might be expected by the application to it of methods recently devised.

HENRY DRAPER MEMORIAL

The number of photographs taken with the 11-inch Draper Telescope is 28, making 18,358 in all; with the 8-inch Draper Telescope, 713, making the total number 38,015. The total number of stellar photographs taken here during the year is 4,155. The first of these instruments has been mounted at Mandeville, Jamaica, where it has been in regular use by Professor W. H. Pickering, mainly in a study of the changes in the surface of the Moon, and in the ellipticity of Jupiter's Satellites. The atmospheric conditions there appear to be exceptionally good both as regards clearness and steadiness of the air.

Miss Cannon has been appointed Curator of Astronomical Photographs in the place of the late Mrs. Fleming. From an examination of the spectra she has found four faint stars in which the line $H\beta$ is bright, and twelve stars whose spectra are composite. The most important work she has undertaken, and one of the largest attempted by this Observatory, is the formation of a Revised Draper Catalogue. This work will include the class of spectrum, the photometric magnitude and the photographic magnitude of more than a hundred thousand stars distributed over the entire sky. As a basis for this catalogue Miss Cannon is classifying five thousand stars a month and has now classified 50,024.

The new star in Gemini afforded an excellent example of the value of our collection of photographs. Two plates taken of the region on March 10, 1912, showed no sign of the star, which appeared at nearly full brightness on two plates taken March 11; on March 12 it was discovered in Norway, and a photograph of its spectrum on March 13 showed that it closely resembled an ordinary star; on March 14 bright lines appeared in its spectrum, and on March 17 the spectrum had entirely changed, and become like those of other Novae.

BOYDEN DEPARTMENT

The Arequipa Station has continued under the charge of Mr. Leon Campbell. The cloudy weather has seriously interfered with the work, although the conditions have greatly improved, and it seems probable that we shall again have the clear weather of former years. The number of photographs taken with the 13-inch Boyden Telescope is 29, making 12,988 in all; 792 photographs have been taken with the 8-inch Bache Telescope, making 43,528 in all. The total number of stellar photographs taken at the station during the year was 2,141. In coöperation with the Smithsonian Institution, a pyrheliometer was mounted at Arequipa, on August 13, 1912, and during 49 days preceding October 1, 1,584 readings were obtained, on 38 days.

BRUCE PHOTOGRAPHIC TELESCOPE

The number of photographs taken with the 24-inch Bruce Telescope was 105, making a total of 10,614, in all. Photographs have been obtained of several of the Selected Areas of Kapteyn. Of the 24 equatorial and 118 southern regions, all have now been taken but 30, of which 10 are equatorial, and 20 are southern.

BLUE HILL METEOROLOGICAL OBSERVATORY

Professor A. Lawrence Rotch, the Founder and Director of the Observatory, died on April 7, 1912. Beginning in 1885, by the most assiduous effort, he built up and brought the Observatory to its present important position in the field of meteorology. Until its formal transfer to the University of Harvard is effected, the Observatory is being maintained and supported by Mrs. Rotch.

The regular observations and records were continued at the Observatory and at its lower station, and the weather forecasts were displayed at the gate daily. The upper air research was continued and kite-flights were made on twelve days named by the International Commission for Scientific Aeronautics, to a mean maximum altitude of 5,990 feet. The maximum altitude attained by the meteorograph in any flight was 10,615 feet. In July and August, Mr. E. G. Linsley, a student in Geology 20f, secured, during fogs, eighteen aerological records by means of kites flown from a motor-boat at Seal Harbor, Maine, as a part of a research on fog commenced during the winter. Mr. L. A. Wells continued as observer-in-charge. Mr. A. H. Palmer was succeeded by Mr. C. F. Brooks as research assistant.

MISCELLANEOUS

Needs of the Observatory. — The needs of the Observatory remain the same as in former years. The greatest need is provision for a number of computers to utilize the vast amount of material contained in the Harvard collection of photographs. It may be compared to a library of two hundred thousand volumes with only a dozen readers. Five thousand dollars a year, or any portion of this sum, could be expended to great advantage in this way, and would yield results wholly out of proportion to its amount. This is well illustrated by the acceptable gift of Mr. George R. Agassiz, who supplied the means for employing two additional assistants. Fireproof buildings are also greatly needed to contain the Library and additional photographs. The sum of thirty thousand dollars would be sufficient for this purpose.

Variable Stars. — The organization for the observation of variable stars has greatly increased during the past year. Photographic maps have now been prepared of 582 variable stars, and the magnitudes of a sequence of comparison stars for each have been determined on a uniform scale. It thus becomes easy to estimate directly the brightness of these variables. As a result, 8,443 observations have been received as follows: Amherst College Observatory, 1,276; Mr. M. W. Jacobs, Jr., Harrisburg, Pa., 1,163; Dr. E. Gray, Eldridge, Cal., 998; Mr. W. T. Olcott, Norwich, Conn., 995; Mount Holyoke College Observatory, 787; Mr. J. B. Lacchini, Firenze, Italy, 610; Vassar College Observatory, 468; Mr. E. L. Forsyth, Needles, Cal., 342; Mr. H. W. Vrooman, Kokomo, Indiana, 318; Rev. T. C. H. Bouton, Hudson, N. H., 256; Mr. A. P. C. Craig, Corona, Cal., 229; Miss H. M. Swartz, South Norwalk, Conn., 188; Mr. F. E. Hathorn, Des Moines, Iowa, 182; Mr. S. C. Hunter, New Rochelle, N. Y., 159; Mr. H. C. Bancroft, West Collingswood, N. J., 130; Mr. C. Y. McAteer, Pittsburgh, Pa., 129; Dr. E. Padova, Catania, Italy, 104; Mr. W. P. Hoge, Pasadena, Cal., 56; Mr. W. N. Bixby, Cambridge, Mass., 22; Mr. E. A. Perkins, Lynn, Mass., 21; and Mr. T. Dunham, Jr., Northeast Harbor, Maine, 10.

All those sending their observations here early in each month are mentioned in a series of articles sent to *Popular Astronomy* showing the brightness of each variable. The observations will also be published in the Annals of the Observatory, if they have not been printed elsewhere. In addition to the observations mentioned above, 1,332 were made here, comprising 1,082 by Mr. P. G. O'Reilly, 210 by Miss I. E. Woods, and 40 by Miss M. Harwood. 342 observations were made at Arequipa, by Mr. L. Campbell. The total number is, therefore, 10,117. The important aims are to secure observations, at short intervals, of the principal variables of long period, and to obtain useful results from large numbers of owners of small telescopes whose work, otherwise, might be of but little value. Both of these conditions seem now to be fulfilled in a highly satisfactory manner.

Observatory of the Rev. J. H. Metcalf. — 209 photographs have been taken by Mr. Metcalf and his assistant, with the 12-inch and 6-inch Telescopes, with an average exposure of 70 minutes. The total number of photographs to October 1, 1912, is 1,362. More than a hundred observations of asteroids have been made. Several new ones were found, three of which had their orbits computed by the Rechen Institute of Berlin. One of these proved to be an old asteroid, which had been lost. The other two were new. A zone for following asteroids has been assigned to Mr. Metcalf by the Rechen Institute. Observations in it are now in progress.

The 16-inch Metcalf Telescope has continued in regular use in Cambridge. 720 photographs have been taken, making the total number 2,017. All of the 110 Selected Areas of Kapteyn, north of the Equator, have been photographed except nine, seven systematic, and two special, regions. The determination of the position of the Moon by photography has now become a part of the regular routine work of this instrument. 183 photographs have been taken, making 289 in all. Plans have been completed for the regular measurement and discussion of these plates under the direction of Professor Russell of Princeton.

Additional Investigations. — The total number of unpublished investigations now in progress exceeds forty. Perhaps the most important of these is the determination of the photographic magnitude of the stars on a uniform scale. Miss Leavitt is still continuing the study of a sequence of stars near the North Pole. By the courtesy of the Director of the Mount Wilson Observatory, photographs taken with the 60-inch Telescope have enabled us to extend this work to stars fainter than the twentieth magnitude. This scale is also being transferred to the forty-nine other regions distributed over the sky and including one near the South Pole. The possibility of determining the photographic magnitudes and colors of stars on a uniform scale with an accuracy equal to that of photometric magnitudes, now seems within our reach.

Another research of the greatest importance is the measurement by Professor Kapteyn of all the stars in his Selected Areas. Photographs of the southern regions were taken with the 24-inch Bruce Telescope in Arequipa, those of the northern regions, with the 16-inch Metcalf Telescope in Cambridge. Measures have been made in Groningen of the diameters and positions of 181,497 stars on these photographs. Plans have been completed for the publication of these measurements in our Annals as soon as a satisfactory method has been found for reducing the diameters to photographic magnitudes. It is expected that the total number of stars will be about 300,000, and that they will fill five volumes of our Annals.

Library. — The Library of the Observatory has been increased by 294 volumes and 1,462 pamphlets, making the total number, 13,824 volumes and 32,734 pamphlets. It is scattered through the various rooms of the Observatory, and continues in constant danger of destruction by fire.

Telegraphic Announcements. — Thirty-two telegraphic announcements have been made, mainly relating to the discovery and observation of comets. They are sent to all who wish for them, free of expense beyond that charged in each case by the telegraph company. The messages are generally sent by "Night Letter," and can thus be transmitted in ordinary language, instead of in cipher, without increased expense, and generally without serious delay.

Cablegrams intended for this Observatory should be addressed "Observatory, Boston," and all telegrams "Harvard College Observatory, Cambridge, Mass." All correspondence should be addressed to the Director.

Thirty-five bulletins have been issued, making the total number 501. The bulletins, beginning with No. 501, are now printed, instead of neostyled, with a great improvement in their appearance and legibility, and but little, if any, loss of time. Many interesting facts are communicated to us and are thus distributed without additional charge to those receiving the telegrams. An example of the promptness with which facts of astronomical importance are now made known throughout the world is afforded by the New Star in Gemini which appeared last spring. Although it was first seen in Norway, observations were obtained of it here and at other American observatories the following evening.

Publications. — A large part of the work of this Observatory is devoted to the publication of results in its Annals. During the last year Volumes **47**, Part **2**; **56**, Nos. **6** and **7**; **59**, Nos. **9** and **10**; **61**, Part **3**; **63**, Part **1**; **71**, No. **2**; **72**, Nos. **1**, **2**, and **3**, have been distributed; **56**, No. **8**, Comparison of Objective Prism and Slit Spectrograms, is nearly ready for the printer; **63**, Part **2**, Sequences of Comparison Stars for 285 Variables, is in preparation; **64**, No. **8**, Basis of Meridian Photometric Magnitudes, is ready for printing; **67**, Catalogue of 8,337 Stars in the Zone $-9° 50'$ to $-14° 10'$, is completed, and will be distributed as soon as it reaches the Observatory; **71**, No. **3**, Standard North Polar Sequence, is nearly ready for the printer; **72**, No. **4**, Observations with the Rumford Photometer, is partly printed; **72**, No. **5**, Light Curves of Eros and other Asteroids, has been sent to the printer; **73**, Part **1**, Blue Hill Meteorological Observatory, 1909, is in process of publication and 35 pages are in type; **74**, General Catalogue of Faint Stars, is about one third in type; **75**, Bond Zones of Faint Equatorial Stars, is nearly all in type. A quarto pamphlet of thirty-six pages, giving the contents of the Annals, **1** to **73**, has been distributed, together with a plan for the sale of these volumes at cost. The set of Annals, from **1** to **70**, is therefore completed and distributed with the exception of **56**, No. **8**; **63**, Part **2**; **64**, No. **8**, and **69**, Part **2**. Portions of **71** and **72** have also been distributed.

From a comparison with previous reports it will be seen that good progress has been made in filling the gaps in the series of Annals, and it is expected that further progress will be made during the coming year.

Ten Circulars have been issued whose numbers, titles, and dates are as follows: —

167. Stars having Peculiar Spectra. 31 New Variable Stars. September 20, 1911.
168. The Variable Star, 232848, Z Andromedae. November 10, 1911.
169. Photometric Observations of Asteroids. December 14, 1911.
170. Adopted Photographic Magnitudes of 96 Polar Stars. February 21, 1912.
171. Five Variable Stars having Secondary Minima. February 21, 1912.
172. Photographic Magnitudes of Asteroids. February 22, 1912.
173. Periods of 25 Variable Stars in the Small Magellanic Cloud. March 3, 1912.
174. Variability of the Pole Star. April 8, 1912.
175. Photometric Measurements of Nova Geminorum, No. 2. July 16, 1912.
176. Nova Geminorum, No. 2. July 29, 1912.

Various other publications by officers of the Observatory are described in the *Harvard University Gazette*, each month.

EDWARD C. PICKERING, *Director.*